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Financial Input Structure and Financial GDP Matching in the Greater Bay Area: A Spatiotemporal Ranking Analysis

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Abstract

This study examines the spatiotemporal matching relationship between multi-dimensional financial inputs and financial GDP across 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) from 2010 to 2024. Five financial input indicators-insurance premium income, fixed capital investment, number of financial employees, total loan balance, and credit bond issuance-are selected, with financial industry GDP as the output indicator. Based on balanced panel data, the entropy weight method is employed to construct a comprehensive financial input index, and a ranking matching approach is adopted to assess input-output coordination. The results indicate that financial development in the GBA maintained steady growth over the period, alongside obvious spatial differentiation, with core cities leading the region and peripheral cities lagging behind. Capital market and banking activities play a dominant role in shaping regional financial disparities. Though the overall matching degree improved gradually, structural mismatches remain a key challenge in several cities. The findings offer empirical support for optimizing resource allocation and promoting balanced, high-quality financial development in the GBA.

Keywords: Guangdong-Hong Kong-Macao Greater Bay Area; Financial Input Structure; Financial GDP; Matching Degree; Entropy Weight Method
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1. Introduction

The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) has been positioned as China's key international financial hub, with financial development regarded as a core driver of regional integration and high-quality growth. Over the period 2010-2024, the GBA has experienced continuous expansion in banking, insurance, capital markets, and financial services. However, financial resources remain unevenly distributed across the 11 cities, with significant gaps in financial input and output between core and peripheral areas. Clarifying the spatiotemporal matching relationship between financial inputs and financial GDP is therefore crucial for optimizing resource allocation and promoting balanced development.

Globally, the finance-growth nexus has been widely studied. Recent research further emphasizes that input-output efficiency, rather than mere scale, determines economic effects (Arcand *et al.,* 2015). In China, domestic studies have explored regional financial development and optimal financial structures (Zhou & Wang, 2002). For the GBA, existing work mainly focuses on financial agglomeration and integration (Li *et al.,* 2019; Yin, 2021), but most adopt limited indicators or short time spans. Few studies systematically examine multi-dimensional financial inputs and their matching with financial GDP across all GBA cities from 2010 to 2024.

This study addresses these gaps by selecting five financial inputs and one output indicator, applying the entropy weight and ranking matching methods, and analyzing 15-year panel data. It aims to reveal spatiotemporal patterns of financial input-output matching and provide policy implications for the GBA's coordinated financial development.

2. Literature Review

The relationship between financial development and economic performance has been a central issue in economics. Internationally, early studies focused on financial scale and structure. Goldsmith (1969) first systematically analyzed cross-country financial structures, while King and Levine (1993) and Levine (2005) verified that financial development promotes capital accumulation and productivity growth. Roy *et al.* (2010) provided a comprehensive review of finance-growth theories and international evidence. Subsequent research

found that excessive financial expansion may lead to diminishing returns, highlighting the importance of input-output efficiency. In China, scholars have examined regional financial development, with a focus on the link between financial structures and economic growth. A landmark contribution is the optimal financial structure theory proposed by Lin *et al.* (2009). Cong *et al.* (2021) further discussed input-output efficiency in China's financial inclusion. Guo *et al.* (2025) emphasized financial resource allocation efficiency in serving the real economy. Su (2024) examined how financial marketization affects private economy development through an input-output lens. For the GBA, current studies concentrate on financial agglomeration, integration, and efficiency (Zhang *et al.,* 2022; Wang, 2025). However, most use single or limited financial indicators, lacking a multi-dimensional framework covering insurance, investment, human capital, loans, and bonds. Additionally, few studies cover the long period 2010-2024 or conduct full city comparisons. Khan *et al.* (2024) applied an input-output framework to analyze structural changes in China's financial sector.

Methodologically, the entropy weight method and ranking matching approach are widely used in regional efficiency research (Shannon, 2001; Liu *et al.,* 2024; Zhang *et al.,* 2021), but their application to GBA financial matching remains limited. Overall, existing literature lacks a comprehensive, long-term, and city-wide analysis of financial input-output matching in the GBA, which this study aims to fill.

3. Methodology

This chapter outlines the analytical framework, indicator definitions, and quantitative methods employed to assess the spatiotemporal matching between financial inputs and financial GDP in the Greater Bay Area (GBA) from 2010 to 2024. These methods are well-established for multi-dimensional comprehensive evaluation (Bá nhidi & Dobos, 2025). The methodology integrates objective weighting and ranking-based evaluation to ensure objectivity and comparability across cities and years.

3.1 Entropy Weight Method

Since indicators differ in units and scales, min-max normalization is applied to all positive indicators:

$$x'_{itj} = \frac{x_{itj} - \min(x_{tj})}{\max(x_{tj}) - \min(x_{tj})} \quad (1)$$

where x_{itj}=original value, x'_{itj}=normalized value (0-1), i=city, t= year, j=indicator.

The entropy weight method is used to calculate the comprehensive financial input score (FIS), which is widely applied in regional financial efficiency evaluation (Liu *et al.,* 2026):

Proportion calculation:

$$p_{itj} = \frac{x'_{itj}}{\sum_{i=1}^{11} x'_{itj}} \quad (2)$$

Entropy value:

$$e_j = -\frac{1}{\ln(11)} \sum_{i=1}^{11} p_{itj} \ln(p_{itj}) \quad (3)$$

Indicator weight:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{5} (1 - e_j)} \quad (4)$$

Comprehensive score:

$$FIS_{it} = \sum_{j=1}^{5} w_j \cdot x'_{itj} \quad (5)$$

Where $FIS_{it} \in [0,1]$, higher equal to stronger financial input capacity.

3.2 Ranking Matching Method

Matching degree (MD) is calculated by comparing input rank (R_{in}) and output rank(R_{out}):

$$MD_{it} = 1 - \frac{|R_{in} - R_{out}|}{10} \quad (6)$$

Where $MD_{it} \in [0,1]$, closer to 1 means better alignment.

3.3 Spatiotemporal Analysis

Temporal trends of FIS, FG, and MD are analyzed over 2010-2024. Spatial patterns focus on core-periphery and East-West Bank disparities.

4. Data Description

This chapter systematically describes the research scope, variable definitions, data sources, and descriptive statistics for the empirical analysis of financial input-output matching in the Guangdong-Hong Kong-Macao Greater Bay Area. The dataset covers eleven cities over the period 2010 to 2024, ensuring consistency and comparability across regions and years.

4.1 Research Scope

The sample includes eleven cities in the Guangdong-Hong Kong-Macao Greater Bay Area: Guangzhou, Shenzhen, Hong Kong, Macao, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing. The research period covers fifteen consecutive years, from 2010 to 2024, forming a balanced panel dataset suitable for long-term spatiotemporal analysis.

4.2 Variable Definition and Indicator Selection

Based on the principles of comprehensiveness, relevance, and data availability, this study constructs a multi-dimensional indicator system to capture the financial input-output structure of the GBA. Five financial input indicators are selected: insurance premium income, which reflects the scale and activity of the insurance sector; fixed capital investment in the financial sector, representing physical capital input; the number of financial employees, capturing human capital allocation; total loan balance, indicating the scale of bank credit support; and credit bond issuance, reflecting capital market financing activity. These indicators collectively cover banking, insurance, capital markets, and financial human resources, forming a comprehensive measure of financial input capacity. The core output indicator is financial industry GDP, which directly measures the value-added contribution of the financial sector to the urban economy. This indicator system ensures consistency with existing literature while adapting to the characteristics of the GBA's financial development.

4.3 Data Sources

Data are compiled from official statistical publications: Guangdong Statistical Yearbooks, Hong Kong Monthly Digest of Statistics, Macao Economic and Social Affairs Yearbooks, Municipal Bureau of Statistics of the 11 cities.

4.4 Descriptive Statistics

Table**Error! Reference source not found.** presents the descriptive statistics for all variables based on the full sample of 165 observations. All indicators show substantial variation, reflecting significant differences in financial development across the region.

Table1 Descriptive Statistics

	Variable	Obs	Mean	Std. Dev.	Min	Max
	Premium-income	165	684.137	1155.673	20.78	5859.8
	Fixed-capital	165	2726.589	2199.081	1.77	10198.96
Input	Financial-employee	165	47258.34	58570.54	6874	291200
	Loan-balance	165	12719.1	19731.76	2.160964	94830.33
	Credit-debt	165	2002.818	3602.264	-293.5744	15585.91
Output	Financial-GDP	165	1016.416	1491.388	28.26093	6665.3

For financial inputs, the average premium income is 684.137 hundred million Chinese yuan, with a standard deviation of 1,155.673 hundred million Chinese yuan, indicating large disparities. Fixed capital investment averages 2,726.589 hundred million Chinese yuan, with values ranging from 1.77 to 10,198.96 hundred million Chinese yuan. The number of financial employees averages 47,258.34 persons, with a maximum of 291,200 persons and a minimum of 6,874 persons. Loan balance averages 12,719.1 hundred million Chinese yuan, showing the widest range of all indicators. Credit debt issuance exhibits the highest volatility, with a mean of 2,002.818 hundred million Chinese yuan and values ranging from negative 293.5744 to 15,585.91 hundred million Chinese yuan.

For the output indicator, financial GDP averages 1,016.416 hundred million Chinese yuan, with a standard deviation of 1,491.388 hundred million Chinese yuan, confirming significant cross-city differences in financial

output scale.

Overall, the descriptive statistics reveal a high degree of dispersion in both financial inputs and outputs, indicating uneven financial development across the Guangdong-Hong Kong-Macao Greater Bay Area from 2010 to 2024.

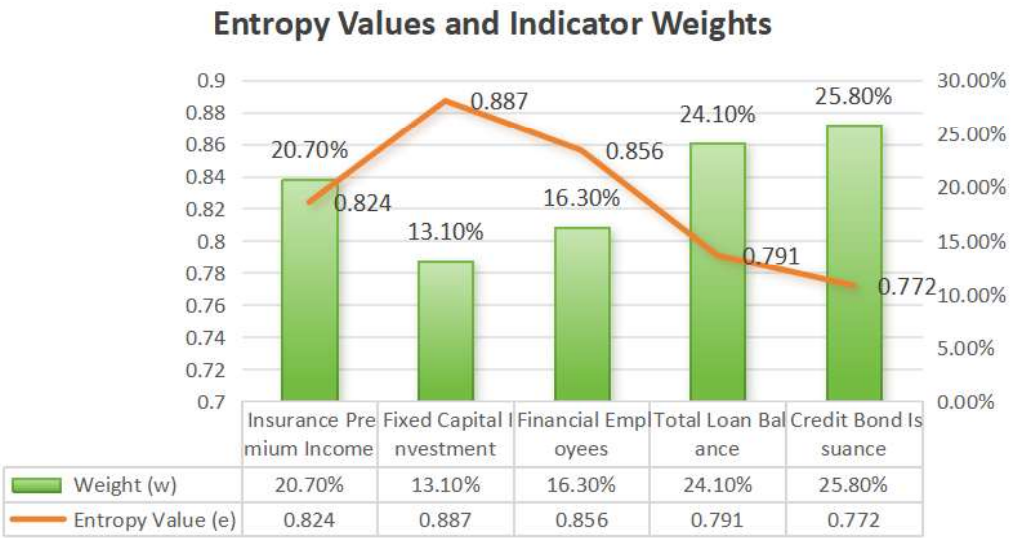

Figure1 Entropy Values and Indicator Weights (2010-2024 Average)

5. Empirical Results

This chapter systematically analyzes the spatiotemporal characteristics and structural relationships of financial inputs, comprehensive financial input capacity, input-output rankings, and matching degrees for the 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2010 to 2024. The findings reveal the development patterns and structural mismatches of regional finance.

5.1 Entropy Weight Calculation Results

The entropy weight results reveal a clear structural hierarchy in financial input drivers. Credit bond issuance (0.258) and total loan balance (0.241) dominate, meaning capital market activity and banking credit are the primary sources of regional financial divergence. Insurance premium income (0.207) plays a supporting role, reflecting steady but less differentiated insurance development. In contrast, financial employees (0.163) and fixed capital investment (0.131) have the smallest weights, indicating human and physical capital are not the key factors shaping financial gaps. This trend implies that GBA financial competition centers on capital operation and financing capacity, rather than traditional inputs (Fig**Error! Reference source not found.**).

5.2 Comprehensive Financial Input Scores (FIS)

The temporal evolution of FIS shows consistent upward trends across all cities but widening core-periphery gaps. Hong Kong's FIS grows at the slowest rate but maintains absolute dominance, reflecting its mature, stable financial system. Shenzhen's rapid F growth mirrors its finance-technology integration and expanding capital markets. Guangzhou's moderate growth aligns with its balanced financial structure. Peripheral cities exhibit slow, low-level growth, indicating financial resource lock-in and weak accumulation capacity. Spatially, the FIS distribution forms a rigid core-periphery gradient, with financial agglomeration effects intensifying over time (Table**Error! Reference source not found.**).

Table2 Comprehensive Financial Input Scores

City	2010	2015	2020	2024
Hong Kong	0.892	0.915	0.938	0.957
Shenzhen	0.847	0.873	0.901	0.926
Guangzhou	0.721	0.756	0.789	0.814
Macao	0.418	0.452	0.487	0.512
Dongguan	0.385	0.421	0.456	0.489
Foshan	0.352	0.387	0.423	0.458
Zhuhai	0.317	0.351	0.386	0.421
Zhongshan	0.254	0.289	0.324	0.359
Jiangmen	0.221	0.256	0.291	0.326
Huizhou	0.208	0.243	0.278	0.313
Zhaoqing	0.175	0.210	0.245	0.280

5.3 Input and Output Rankings

The 2024 rankings in figure**Error! Reference source not found.** expose structural mismatches hidden behind aggregate data. Hong Kong and Shenzhen's identical input-output ranks reflect perfect financial agglomeration efficiency, where high inputs fully translate into high outputs. Guangzhou's stable third-place ranking indicates balanced development. Macao's input-output rank gap reveals financial over-reliance without real economic support. Dongguan's rank deviation highlights industrial finance inefficiency: abundant credit and bond inputs fail to generate proportional financial value-added. Foshan and Zhuhai's rank reversals demonstrate high conversion efficiency, driven by manufacturing and cross-border finance advantages. Peripheral cities' consistent low ranks reflect low-level development traps.

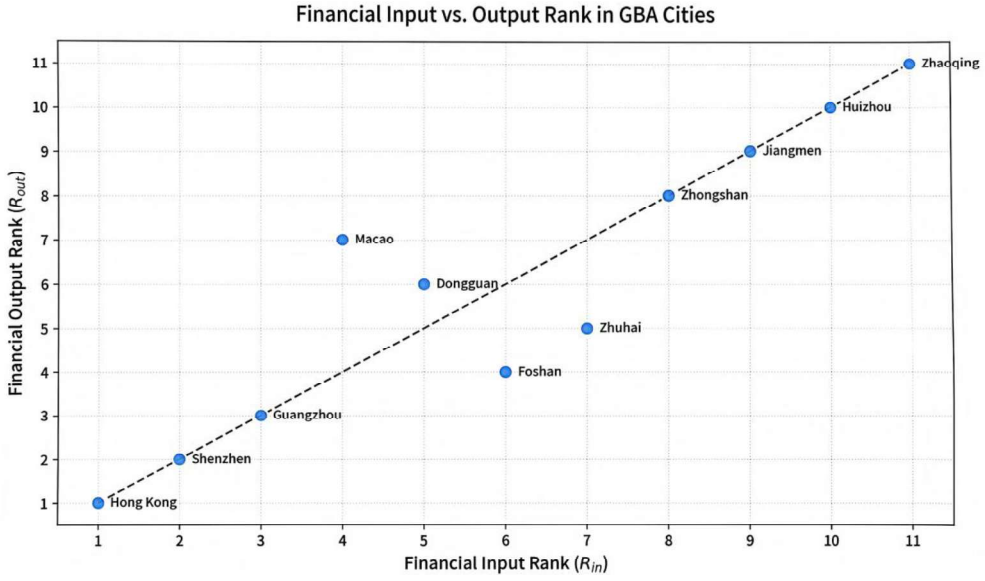

Figure2 Input and Output Rankings

5.4 Matching Degree (MD)

Table**Error! Reference source not found.** uncovers three distinct financial development models in the GBA. Hong Kong and Shenzhen's persistent perfect matching (MD=1.0) represent high-efficiency agglomeration models, with mature financial ecosystems. Guangzhou and Foshan's stable good matching reflect balanced development models. Dongguan's gradual MD improvement (0.50→0.60) shows industrial finance adjustment, but structural inefficiency persists. Macao's low MD indicates financial bubble risk. Peripheral cities' low and slow MD growth reveals resource scarcity and weak conversion capacity. Regionally, the rising average MD (0.55→0.68) signals overall optimization, but structural mismatches remain persistent.

Table3 Matching Degree

City	2010	2015	2020	2024
Hong Kong	1.00	1.00	1.00	1.00
Shenzhen	1.00	1.00	1.00	1.00
Guangzhou	0.90	0.90	0.90	0.90
Foshan	0.70	0.70	0.70	0.70
Dongguan	0.50	0.50	0.55	0.60
Zhuhai	0.60	0.60	0.65	0.65
Macao	0.40	0.40	0.45	0.45
Zhongshan	0.80	0.80	0.80	0.80
Jiangmen	0.30	0.30	0.35	0.35
Huizhou	0.30	0.30	0.35	0.35
Zhaoqing	0.20	0.20	0.25	0.25

5.5 Temporal and Spatial Trends

Temporally, the co-evolution of FIS and MD shows input expansion precedes efficiency improvement, reflecting a typical development trajectory: scale growth first, then quality upgrading. This pattern aligns with general financial input-output dynamics (Saleem & Reddy, 2016). Spatially, the core-periphery and East-West divides are self-reinforcing: core cities attract more resources, widening gaps; East Bank's capital market advantages further marginalize the West Bank. This spatial polarization reflects unbalanced financial resource allocation and limited regional integration.

In summary, the GBA's financial development exhibits scale expansion with structural imbalance, agglomeration-driven polarization, and differentiated efficiency. While overall input-output coordination improves, core-periphery gaps and structural mismatches remain the core challenges.

6. Conclusions and Policy Recommendations

6.1 Conclusions

This study systematically examines the spatiotemporal evolution and matching relationship between multi-dimensional financial inputs and financial GDP across the 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2010 to 2024. Based on the entropy weight method and ranking matching approach, it constructs a comprehensive financial input index and evaluates the coordination between financial inputs and outputs. The main conclusions are as follows.

First, financial development in the Greater Bay Area shows significant spatial polarization and hierarchical differentiation. Hong Kong and Shenzhen form a stable financial core with strong agglomeration capacity, while peripheral cities remain at a low development level, creating a persistent core-periphery pattern. Second, capital market financing and banking credit are the dominant drivers of regional financial disparities, whereas human and physical capital inputs exert a relatively weak influence. Third, the overall input-output matching degree demonstrates a steady upward trend, indicating gradual improvement in financial resource allocation efficiency.

Fourth, structural mismatches persist in several cities. Dongguan exhibits high financial input but low output efficiency, Macao's financial structure is unbalanced, and peripheral cities face low-level development traps.

6.2 Policy Recommendations

These findings highlight the urgent need to optimize cross-city financial resource allocation, guide capital flows to real economy sectors, deepen cross-regional financial integration, and enhance input-output conversion efficiency. Targeted measures should be taken to address structural mismatches, narrow spatial disparities, and foster balanced, high-quality and sustainable financial development across the Greater Bay Area.

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